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Scraping and Banding Apple Trees as a Supplementary Codling Moth Control Measure in the Pacific Northwest

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INTRODUCTION

Scraping and banding apple trees to trap the larvae of the codling moth (*Carpocapsa pomonella* (L.)) have long been common supplementary control practices. During the last century these practices were followed very extensively, but with the advent of spraying they fell more or less into disuse. However, in about 1927 difficulties encountered with spray residues and the development of chemically treated bands by Siegler *et al.* (*10, 11, 12*)[2] and by others gave renewed impetus to scraping and banding.

The band developed by Siegler and other workers consists of corrugated paper strips coated with beta-naphthol dissolved in a heavy

[1] Acknowledgment is made to E. J. Newcomer, in charge of the Yakima, Wash., laboratory of the Bureau of Entomology and Plant Quarantine, where these studies were made, for suggestions throughout the work, and to F. P. Dean, also of this laboratory, for assistance with the statistical analyses.

[2] Italic numbers in parentheses refer to literature cited, p. 22.

lubricating oil. The chemical kills the larvae that enter. The older types of band, consisting of burlap, building paper, or other material, had to be removed at intervals of 10 to 14 days, so that the larvae might be destroyed by mechanical means. The new chemical bands work automatically and are allowed to remain undisturbed until well after fruit harvest or until the following spring.

The bands are applied to the trees in June, just before the first larvae leave the fruit.

All but a few of the larvae caught before the end of July would have produced a second brood of moths during the current season. Only a few of the larvae caught after the third week in August, however, would have changed into moths. Banding, therefore, is immediately effective during the fore part of the season in reducing the second-brood population the same season, but late in the summer the effect is greatest in reducing the overwintering larvae.

It is necessary to scrape the rough bark thoroughly from the trees to obtain the maximum benefit from banding. Scraping serves a two-fold purpose: (1) To remove and destroy the hibernating larvae and thereby reduce the potential moth population for the following season, and (2) to eliminate the cocooning quarters for the later full-grown larvae after they leave the fruit, thus inducing a greater proportion of them to enter the bands and be destroyed. In this way scraping and banding constitute one supplementary control measure, although either will afford some benefit if used alone.

Experimental scraping and banding and related studies have been carried on in different parts of the country under a great variety of conditions. Some of this work is discussed in the following references: Baker (*1*, *2*), Gould and Geissler (*4*), Marshall (*5*), Newcomer (*7*), Newcomer et al. (*8*), Steiner (*13*, *14*), Steiner and Ackerman (*15*), Steiner and Marshall (*16*), Woodside (*17*, *18*), Worthley (*19*), Yothers (*20*, *21*, *22*), and Yothers and Carlson (*24*, *25*, *26*).

This circular brings together work done by the present authors in the Northwest during the period 1935–43, after which this phase of the work was discontinued. Comparatively little emphasis is now being placed on scraping and banding for codling moth control, because of the use of the highly effective insecticide DDT, the greatly increased cost of labor and the development by the authors (Yothers and Carlson *27*) of trunk sprays, which are about as effective as scraping and banding and are less expensive and require less labor.

LOCATION OF OVERWINTERING LARVAE

Over a period of 6 years near Yakima, Wash., the location of the larvae on or near 80 trees in 8 orchards that had never been scraped, and on 104 trees in 11 orchards that had been scraped and banded the preceding season, was recorded after minute examination. Larvae on trunks, in the lower crotches, and in the soil at the base of the trees were classed as on the trunks; those on the scaffold limbs above their union with the trunk and as far up as the rough bark extended, or to secondary limbs, were classed as on scaffold limbs; while those on secondary and smaller branches beyond scaffold limbs were classed as on the branches.

The trash and soil were sampled as follows: The surface trash from one-fourth of the area (a 90° sector) under a tree, for a distance of

6 feet from the tree base, was run through a sifting machine (Carlson and Yothers *3*), and the residue was carefully examined for cocooned larvae. The soil below the place where the trash had been removed was also sifted and the residue examined. The number of individuals recovered from the trash or soil was then multiplied by four to obtain the total numbers presumably present under the tree. The results of these studies are summarized in table 1.

TABLE 1.—*Distribution of overwintering codling moth larvae on apple trees, 1938–43*

Treatment of trees in previous years	Total larvae	Larvae on or in—					Larvae per tree
		Trunks	Scaffold limbs	Branches	Trash	Soil	
Not scraped and banded	*Number* 13, 435	*Percent* 42	*Percent* 43	*Percent* 13	*Percent* 1	*Percent* 1	*Number* 168
Scraped and banded	2, 275	20	21	50	8	1	22

The larval populations in the trash and soil appear to be of little importance in commercial orchards in the Yakima district. The population on the trees that had been scraped and banded the preceding season or seasons had been markedly reduced by the treatment. On these trees the rough bark had been cleaned off and the trash against the base of the tree cleared away, so that there were few places for the larvae to hide. Consequently, most of them settled in the sheltered spots available on the branches, in pruning wounds, and in the trash on the ground.

In 46 trees scraped and banded the previous year and examined in the spring before moth emergence, 1,219 codling moth larvae hibernated as follows: 32 percent in rough bark, 22 percent in pruning wounds and broken limbs, 16 percent in crotches, 11 percent in knots, 11 percent in trash and soil beneath the trees, and 8 percent in miscellaneous places. In 37 trees not scraped and banded and examined in the spring before moth emergence, 4,072 larvae hibernated as follows: 63 percent in rough bark, 4 percent in pruning wounds and broken limbs, 23 percent in crotches, 3 percent in knots, 4 percent in trash and soil beneath the trees, and 3 percent in miscellaneous places.

Most of the rough bark had been removed in scraping and the crotches were largely cleaned out; therefore the percentage of worms in these places was reduced. In all other locations the percentages were greater in scraped and banded trees. The theory that scraping drives a larger proportion of the larvae into the less accessible places, thereby prolonging moth emergence, is substantiated by these figures; however, although the percentage of larvae driven to these locations was greater, no larger numbers were found there.

The location and type of hibernating places were determined in March, April, and early in May, and do not represent a stationary condition. There is probably considerable variation between fall and spring percentages of larvae in the different locations. Many of the larvae that have spun up in the trash and fruit under the trees and in the soil at the base of the trees, and the more exposed individuals on the trunk, scaffold limbs, and branches had doubtless been destroyed

by birds and rodents. The larvae that had not been disturbed by spring were the ones found and recorded in these studies.

Many larvae were also found in such places as rotten spots on trees, empty sacks, papers, old clothes, broken boxes, spliced tree props, dried fungus growths on the trees, under birds' nests, and in canker wounds.

PERCENTAGE OF LARVAE REMOVED BY SCRAPING

Eight Jonathan and six Winesap trees in three orchards were scraped in the regular manner, and the scrapings were examined for larvae. On the Jonathan trees 82 percent of the larvae were removed by scraping, and on the Winesap trees 77 percent. Afterward the trees were carefully examined for larvae that had been missed or were inaccessible. Throughout moth emergence the trees were examined for empty pupal cases. The Jonathan variety, because of the absence of cracks, holes, and sprout clusters, lends itself more readily to thorough scraping than do the Winesap, the Delicious, and certain other varieties.

In a single study of four Jonathan trees that had been scraped the previous season, only 50 percent of the larvae were removed. Apparently, after the first scraping, the larvae were forced into the more inaccessible situations and therefore were not so readily removed by a later scraping.

PROPORTION OF LARVAE CAUGHT IN BANDS AFTER LEAVING THE FRUIT

The proportion of the larvae that leave the fruit and are captured in chemically treated bands depends on the variety, age, and size of the trees. The number of larvae caught depends on surface characteristics, such as roughness of the trunk and scaffold limbs after scraping, the number of cracks, knot holes, broken limbs, and crotches inaccessible to scraping, as well as the thoroughness of scraping and the fit of the bands.

Two methods of making such determinations were employed. In each method the trees were first carefully scraped and banded, about the middle of June, with regular corrugated-paper beta-naphthol bands. In one method all the dropped and harvested wormy fruit was cut open and examined, the dropped fruit being examined every 30 days and both dropped and wormy fruit at harvesttime, and the number of exit holes was recorded. At the same time, or a few days later, the bands on these trees were removed and examined for the total number of larvae caught. The final results of these tests on four leading commercial varieties over a period of 7 years in several orchards, are given in table 2. There was considerable variation in the percentage of larvae captured, both for years and varieties.

The other method differed from the foregoing in that, starting about July 10, and ending at harvesttime, all apples on each tree and the dropped fruits on the ground were examined every 30 days for exit holes. Each exit hole for each tree was recorded, and on the same dates the bands were removed and the number of larvae caught was also recorded. New bands were then placed, since those examined were unfit for replacement. After the harvest examination of the fruit, the bands were usually allowed to remain for a few days, to allow

TABLE 2.—*Proportion of larvae that left the fruit and were captured in beta-naphthol bands, 1935–41*

Variety	Year	Trees	Larvae captured—		
			Leaving fruit	In bands	
		Number	*Number*	*Number*	*Percent*
Jonathan	1935	5	213	183	86
	1936	9	1, 109	698	63
	1937	26	6, 098	3, 769	62
	1938	19	10, 849	7, 274	67
	1939	18	2, 545	1, 321	52
	1940	6	2, 517	1, 290	51
	1941	6	166	86	52
Total		89	23, 497	14, 621	62
Rome Beauty	1939	2	268	119	44
	1940	10	938	465	50
Total		12	1, 206	584	47
Winesap	1936	2	28	14	50
	1937	7	1, 312	794	61
	1938	4	1, 598	625	39
	1939	6	412	165	40
	1940	8	1, 116	396	35
	1941	12	165	54	33
Total		39	4, 631	2, 048	43
Delicious	1935	5	859	691	80
	1936	6	213	117	55
	1938	4	1, 558	487	31
	1939	6	1, 180	353	30
	1940	6	575	158	27
Total		27	4, 385	1, 806	45
Grand total		167	33, 719	19, 059	57

any worms that had recently left the fruit to enter them. Dropped fruits at the preharvest examinations and picked wormy fruits were cut open to make certain that the larvae had left. In every test but one a larger percentage of the larvae were caught in the three preharvest examinations than in the after-harvest examinations. For all orchards and in all preharvest examinations the percentage caught before picking averaged 82, but the after-harvest percentage dropped to 40. In other words, about twice as many of the larvae left the fruit before the preharvest examination as left it thereafter. The seasonal average of larvae captured was 61 percent, which is substantially the same as the 57 percent shown by the first method (table 2).

Since the growing larvae feed within more than one apple, it seems that by this method the number of larvae caught in the bands, as compared with the number of exit holes, is greatly underestimated. Nel (*6*) stated that a single well-grown larva can leave several exit holes against which but one capture in the bands can be recorded.

Baker (*2*) concluded that the effect of banding (and scraping) on moth emergence and larval hibernation was much greater than was indicated by the percentage of larvae caught in the bands after emerging from the fruit.

LARVAE CAUGHT IN TRUNK BANDS AND LIMB BANDS

Experiments to determine the percentage of larvae leaving the fruit that are caught in bands on trunks only and on both trunk and limbs were made on 139 trees of the Jonathan, Winesap, Delicious, and Rome Beauty varieties. The methods followed were similar to those already described, and involved periodic examinations of the bands and of the fruit on the tree. The results of these tests are summarized in table 3.

TABLE 3.—*Larvae caught in bands on trunks only and on both trunks and scaffold limbs, 1937–41*

Year	Trees	Larvae in bands			
		On trunks only		On trunks and scaffold limbs	
	Number	*Number*	*Percent*	*Number*	*Percent*
1937	33	2, 016	56	2, 547	67
1938	24	1, 239	33	2, 276	56
1939	32	732	36	1, 241	52
1940	32	2, 309	46	3, 060	65
1941	18	140	42	261	61
Total and average	139	6, 436	43	9, 385	61

In 1936–39 three methods of banding were tried in weekly rotation on the same trees—trunk bands, limb bands, and both kinds. In these tests on 357 trees of 4 varieties in 10 orchards, 41,713 larvae were caught in bands on trunks, 53,773 in bands on limbs, or 29 percent more than in trunk bands, and 62,734 in a combination of both, or 17 percent more than in limb bands alone and 50 percent more than in trunk bands alone.

In 1939 tests were made to determine the numbers of larvae caught in bands on trunks and on scaffold limbs. On 408 trees in 5 orchards, 65,819 larvae were captured, of which 17,871 were in trunk bands and 47,948 were in limb bands, or 27 and 73 percent, respectively. In other words, limb bands captured 2.7 times as many larvae as trunk bands. However, limb bands require an average of 2.1 times as much banding material as trunk bands.

In two tests in which badly infested trees were banded with 3 bands on each limb, about 1 foot apart, an average of 21 limb bands per tree, 73 percent of the total larvae captured were in the upper bands, 18 percent in the middle bands, and 10 percent in the lower bands. In another test where two bands were placed on each trunk, the lower band caught 56 percent of the total. Both these tests indicate that not all the larvae stop in the first band they come to.

EFFECT OF DENSITY OF INFESTATION ON NUMBER OF LARVAE CAUGHT IN LIMB BANDS AND TRUNK BANDS

Where the infestation was low, averaging only 10 larvae per tree, 66 percent more larvae were caught in limb bands than in trunk bands, and 106 percent more were caught in both types of bands than in bands on trunks only. On the other hand, where the infestation was high, averaging 265 larvae per tree, only 25 percent more were in limb bands than in trunk bands, and 47 percent more in both types of bands than in trunk bands alone. This difference may be explained by the fact that in more severe infestations a greater proportion of wormy apples fall to the ground, and a larger proportion of the larvae from these fallen fruits get into the trunk bands than into the bands on the scaffold limbs farther up.

INFLUENCE OF APPLE VARIETY ON NUMBER OF LARVAE CAUGHT

Varieties of apple differ in their adaptability to scraping and banding. Jonathan and Rome Beauty are particularly well suited for maximum scraping and banding efficiency, whereas Delicious and Winesap are much less so, because of their knotty limb surfaces, cracks, crotches, and numerous scallops on the trunks (figs. 1, 2, and 3).

These differences are reflected in the varying numbers of larvae caught on trees of the four varieties tested (table 2). The total captures are also influenced by the susceptibility of the different varieties to codling moth attack, a factor not directly involved in the work reported on in this circular.

The more difficult a tree is to scrape and band the less efficient the bands are in capturing the larvae. The more severely infested varieties, such as Jonathan, should be given special attention in the treatment, not only to protect their own crop but also that of less susceptible neighboring varieties.

TIME REQUIRED FOR BETA-NAPHTHOL BANDS TO KILL

In tests of freshly applied bands on tree trunks in the orchard, all the larvae that had been in the bands from 24 hours to 8 days were killed by the chemical, whether the bands were removed from the trees and kept in the orchard at temperatures of 60° to 98° F. or were taken to a semidark, cool basement at 66° to 68°. Tests in which orchard conditions were simulated showed that all the larvae in bands on the sunny side of a section of apple limb 4 inches in diameter were killed within 8 hours. An exposure of several hours in the sunshine and overnight killed all the larvae in 18 hours. On the shady side of the same sticks all larvae were killed in 24 hours. With lower temperatures, as in the basement at 66°, only 90 percent were killed in 24 hours. In properly prepared bands the chemical kills the larvae so quickly that few are able to transform to pupae.

FIGURE 1.—Trunk of Jonathan apple tree showing characteristic rough bark.

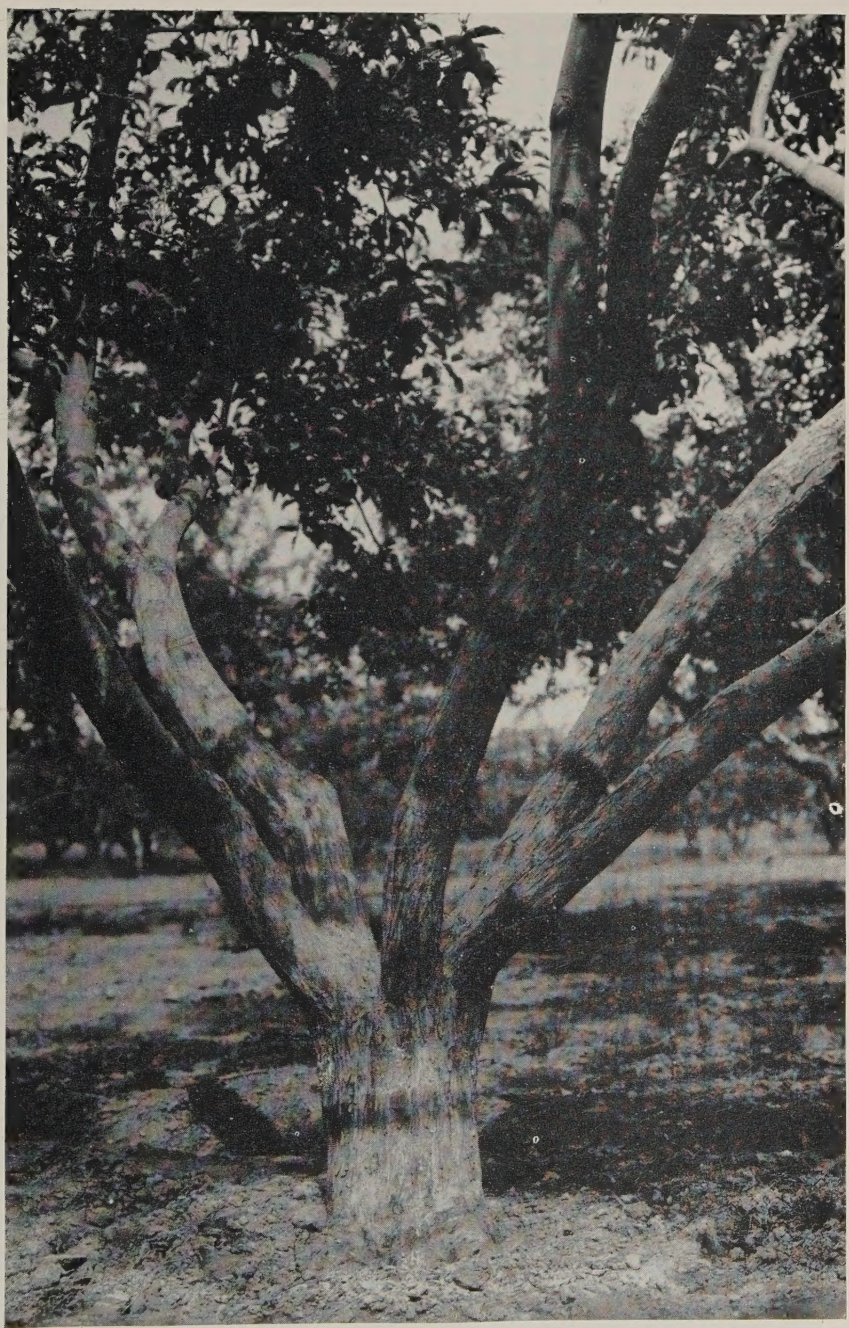

FIGURE 2.—Jonathan apple tree that had been scraped and banded on trunk and limbs, after the bands had been removed at the end of the season. The discoloration from the oil is in the outer bark only.

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FIGURE 3.—Delicious apple tree showing split crotch and many-scalloped trunk. Least benefit is gained from scraping and banding this type of tree.

STICKY BANDS AS COMPARED WITH BETA-NAPHTHOL BANDS

Two proprietary sticky-banding or barrier materials are used in the Yakima and Wenatchee districts, primarily as barriers for mites and climbing cutworms but also from time to time for capturing codling moth larvae. In orchard tests to compare the efficiency of the two types of bands, the beta-naphthol bands caught 13 times as many worms per inch of band as did the sticky bands. The latter cannot be depended on as an effective barrier or trap for the codling moth larvae.

LARGE-SCALE ORCHARD TESTS OF SCRAPING AND BANDING

A large-scale experiment was begun at Yakima in July 1935 to determine what control could be obtained from scraping and banding blocks of several acres of apple trees as a supplement to the spraying program. This experiment was continued and enlarged upon for 8 years, during which time tests were made in six orchards, on five common commercial varieties of apples grown in the Pacific Northwest—Jonathan, Winesap, Rome Beauty, and a few Delicious and Arkansas Black.

Experimental Methods

The tests were set up with plots of several acres of scraped and banded trees, with adjoining plots of the same varieties that were not scraped and banded. All the plots received the same spray treatments. On the banded trees the rough bark was scraped from the branches, scaffold limbs, and trunks, including 2 to 3 inches below the ground line. Scrapings were caught on a tarpaulin spread under the tree and were burned. Except as otherwise noted, the scraping was done in the spring before moth emergence began. Only proprietary bands were used in these tests. The bands contained approximately 2 pounds of beta-naphthol to each 100 linear feet of 2-inch band, in the proportion of 1 pound of beta-naphthol to 1½ pints of heavy oil. They were applied about the middle of June, in time to capture the first larvae to leave the fruit.

The bands were removed either in November after fruit harvest or the following spring. The number of larvae captured in the bands was recorded for each tree. The control value of scraping and banding was determined by examining representative samples of harvested and dropped fruit from the treated and the check plots.

Samples of 250 apples per count tree were taken at random, an equal number from each box of picked and dropped fruit, as discussed by Newcomer, Dean, and Cassil, (*9*). Samples were taken from each variety that was sufficiently represented in both treated and check plots. Records were made of the number of apples that were clean, wormy, and stung, and of the number of worms and stings per injured apple.

Description of Plots

The first tests were made in the Gilbert orchard in July 1935. Large bearing trees on approximately 10 acres were scraped and banded.

Trees on an adjoining 10 acres were left unscraped and unbanded as a check. Both plots received the same regular spray treatment. Each plot contained two varieties, alternating 2 rows of Jonathan and 6 rows of Winesap. Each plot consisted of 33 rows of 16 trees, or approximately 528 trees. The trees were thoroughly scraped and the bands applied on July 13–16. Since the scraping was not done until July 1–13, long after all spring-brood moths had emerged and after some of the first-brood larvae had already left the fruit, little immediate value was anticipated for this test.

Examination of the harvested fruit showed substantial results in favor of the scraped and banded plot, as compared with the adjoining unsprayed, unbanded plot. Obviously, this apparent difference could have been in the original codling moth population.

In 1936 the same test was again used in the Gilbert orchard. The scraping was done before moth emergence and the bands were applied by the middle of June, before larvae began leaving the fruit. The crop in both plots was much cleaner than in 1935, probably owing to a much more intensive and better spray program.

In 1937 the test in the Gilbert orchard was the same as in 1935 and 1936, except that one of each double row of Jonathan in the treated plot and two rows only in the check plot had been removed by the grower. In 1938 the test was the same as in 1937. In 1939 two more rows of Jonathan had been removed in the check plot, leaving one row of this variety to each six rows of Winesap, the same as in the treated plot. This year the third cover spray was omitted in the treated plot but not in the check plot. In 1940 the treated plot received two sprays less (the third and fifth cover sprays) than the check plot and the remainder of the orchard.

Work in the Zier orchard was started in 1936. The scraped and banded plot and the check plot each consisted of approximately 400 trees or about 10 acres. There were six varieties in each plot—Winesap, Jonathan, Delicious, Arkansas Black, Rome Beauty, and Spitzenberg. In the treated plot all the trees were scraped and banded, but only the first four varieties were examined at harvest-time. The test in 1937 was the same as in 1936, except that some Spitzenberg trees had been removed. In 1938 both plots were reduced in size by removing a number of trees. The treated plot in 1938 included 278 trees, and the check plot 330.

In 1938 an experiment was begun in the Bounds orchard, adjoining the Zier tract. The scraped and banded plot consisted of 453 trees and the check plot of 501 trees. Counts were made on Winesap, Jonathan, Delicious, and Arkansas Black. Similar tests were made in 1939.

In 1939 a test was begun in the Buchanan orchard, in a different part of the district, using 368 scraped and banded trees and 332 check trees. An unsprayed orchard was across the road from the scraped and banded plot. In 1940 the treated plot was enlarged by 4 rows and the check was reduced 4 rows. The adjoining neglected orchard of the previous season was well cared for and was cleaner than the experimental tracts.

In 1940 a test was set up in the Bannister orchard, consisting of approximately 30 acres of 30-year-old trees, which was more isolated than any used before. On three sides there were no orchards for a mile or more, and on the fourth side this orchard was separated from the nearest neighboring one by a distance of more than 500 feet. The scraping was not completed until May 9, when moths had been emerging for 2 or 3 weeks. One-half of the orchard was scraped at this time and after July 1 the scraped area was increased to about two-thirds (1,150 scraped trees and 420 unscraped trees). That part scraped in May was banded early in June and the remainder in July. No count trees were taken from the latter section, but it served as a buffer block.

The following varieties were scraped and banded: Winesap, Delicious, Rome Beauty, and Arkansas Black, also some Jonathan trees that were partly grafted to Delicious. Arkansas Black and Jonathan were not used in harvest counts.

In 1941 only the Bannister orchard was used. The trees were scraped by April 20, before moths emerged, and the bands were applied on two-thirds of the scraped tract by June 26 and on the other third by July 2, a few days late for catching the earliest worms.

In 1942 a test, which was a part of another experiment, was begun in the Briskey orchard with 200 Winesap trees in the treated plot and 70 trees in the check plot.

Results of Tests

The results of these 14 experiments, involving 47 tests of varieties for the 8-year period 1935–42, are summarized in table 4. They show that in general the scraped and banded plots had more clean fruit, fewer wormy apples, and fewer stings than the unscraped, unbanded plots. These gains from scraping and banding were made notwithstanding a number of adverse conditions. It was necessary to have an unscraped and unbanded check plot in each orchard, and from this untreated plot infestation doubtless spread into the treated area, somewhat reducing the potential control. In one orchard the treated plot was joined on the north by a heavily infested, unsprayed orchard, the effects of which were very noticeable, especially in the nearest several rows. Large-scale community or orchard-district scraping and banding would obviously give the best results.

For all varieties (table 5), analysis of variance shows all differences except in the Rome Beauty variety, to be highly significant at odds of 99 to 1 in favor of the scraping and banding treatment. Although the Rome Beauty plots showed from 1.6 to 4.2 times as many worms per 100 apples in the untreated as in the treated plots, the 4 tests showed too great a variance to be statistically significant. In the check plots each variety averaged 2 to 2.3 times as many worms per 100 apples as were found in the treated plots.

TABLE 4.—*Results of scraping and banding apple trees for codling moth control, 1935–42*

Year and orchard	Variety	Count trees		Clean apples		Worms per 100 apples		Stings per 100 apples	
		Treated	Check	Treated	Check	Treated trees	Check trees	Treated trees	Check trees
1935		*Number*	*Number*	*Percent*	*Percent*	*Number*	*Number*	*Number*	*Number*
Gilbert	Winesap	27	27	82	56	4.0	9.6	25.7	70.1
	Jonathan	9	9	71	40	19.6	54.4	24.8	64.4
1936									
Gilbert	Winesap	32	32	91	84	.5	1.4	9.6	18.5
	Jonathan	9	9	88	80	5.1	6.5	11.4	23.6
Zier	Winesap	7	8	82	55	.2	5.6	23.4	83.0
	Jonathan	10	10	73	63	10.5	16.8	32.7	41.3
	Delicious	13	15	77	55	4.0	13.7	33.5	76.6
	Arkansas Black	9	9	82	66	.8	4.6	25.9	56.6
1937									
Gilbert	Winesap	32	32	92	89	.1	.2	9.0	13.6
	Jonathan	8	6	94	89	.7	3.1	6.0	12.2
Zier	Winesap	13	9	87	64	1.2	6.2	14.1	56.8
	Jonathan	14	13	83	45	7.3	45.2	17.3	70.2
	Delicious	14	14	74	38	10.2	45.0	31.5	103.7
	Arkansas Black	12	10	82	55	2.2	10.7	23.2	81.9
1938									
Gilbert	Winesap	32	32	91	86	1.3	2.7	9.6	15.5
	Jonathan	9	8	75	69	12.9	16.3	22.0	28.9
Zier	Winesap	7	7	83	48	.7	7.2	18.1	76.4
	Jonathan	3	7	42	24	29.8	54.2	82.3	117.2
	Delicious	9	9	59	36	13.0	27.6	50.6	110.0
	Arkansas Black	8	7	63	31	5.0	16.1	48.5	124.6
Pounds	Winesap	21	21	66	51	2.2	4.5	49.6	82.8
	Jonathan	7	6	26	19	50.4	66.2	148.5	179.5
	Delicious	7	7	43	30	22.4	49.1	101.5	151.8
	Arkansas Black	7	7	46	34	11.2	19.4	98.9	149.5

1939									
Gilbert [1]	Winesap	32	32	70	66	3.5	5.2	40.9	48.7
	Jonathan	9	9	59	49	22.3	21.5	45.4	76.9
Bounds	Winesap	23	23	77	61	2.6	6.2	31.7	60.1
	Jonathan	9	9	66	47	12.8	26.5	38.0	77.4
	Delicious	10	10	55	39	15.3	22.4	57.2	114.0
	Arkansas Black	7	7	64	41	10.9	21.0	54.8	129.4
Buchanan	Winesap	25	25	76	64	1.7	5.5	28.6	46.7
	Jonathan	6	6	46	22	20.1	51.4	71.0	147.1
	Delicious	10	10	51	37	13.3	20.1	74.5	121.6
	Rome Beauty	6	6	57	27	12.8	53.3	60.0	158.9
1940									
Gilbert [1]	Winesap	32	32	65	80	10.2	4.2	43.3	22.2
	Jonathan	8	8	56	64	27.7	15.8	40.0	35.7
Sundquist	Winesap	25	25	64	45	8.0	13.4	51.5	100.0
	Jonathan	10	10	68	41	16.7	46.2	29.3	74.6
	Delicious	10	10	63	40	14.7	28.4	46.2	107.1
	Rome Beauty	6	6	67	42	13.2	25.9	43.0	104.0
Bannister	Winesap	36	34	58	55	8.1	10.7	59.1	65.1
	Delicious	22	21	54	49	13.1	16.8	66.5	74.6
	Rome Beauty	16	16	51	39	14.9	24.4	80.3	116.6
1941									
Bannister	Winesap	72	30	47	24	9.1	16.3	93.4	183.3
	Delicious	17	12	50	27	7.4	17.2	75.8	155.2
	Rome Beauty	23	14	43	22	15.7	26.8	114.0	165.9
1942									
Briskey	Winesap	20	20	68	50	12.7	23.2	37.8	65.2
Total or average		672	602	66	48	10.2	21.9	47.2	90.1

[1] Tests in the Gilbert orchard for 1939 and 1940 are not included in the totals, since one spray was omitted in 1939 and two in 1940 in the scraped and banded block.

TABLE 5.—*Results of scraping and banding apple trees for codling moth control, in comparison with results on plots not scraped and banded, 1935–42*

Variety	Number of tests	Mean number of worms per 100 apples [1]	
		Treated	Untreated
Arkansas Black	5	6. 0	12. 0
Delicious	9	12. 6	26. 7
Jonathan	11	16. 9	35. 2
Rome Beauty	4	14. 2	32. 6
Winesap	14	3. 7	8. 1

[1] All differences highly significant at odds of 99 to 1, except with Rome Beauty, which was not significant because of the variance in the 4 tests.

As shown in the final results (table 4), the percentage of worm- and sting-free fruit was increased by the treatment for all plots, varieties, orchards, and years. At the same time the stings per 100 apples were reduced from 90 to 47, a reduction of 48 percent.

METHODS OF SCRAPING AND BANDING

Scraping

Thorough scraping requires the removal of all rough bark and, as far as possible, the cleaning out of all other places where the larvae may hide on branches, scaffold limbs, and trunk, including a depth of 2 to 3 inches in the soil at the base of the tree. Unnecessary cutting of the live bark should be avoided. "Peeling" the trees, as is sometimes done, is injurious to them, a waste of time, and entirely unnecessary either in removing the larvae or in preparing the trees for banding.

Scrapings should be caught in tarpaulins spread under the trees and should be burned whenever five or six trees have been finished. A cupful of stove oil or used crankcase oil poured over each pile of scrapings will facilitate starting the fire. Old beta-naphthol bands, discussed elsewhere, may also be used advantageously to aid in burning the scrapings.

Scraping can be done at any time between fruit harvest and moth emergence the following spring, usually before mid-April in the Pacific Northwest. After moths start to emerge much of the effectiveness of the operation will be lost; however, it is better to have the scraping completed after a few moths have emerged than not to get it done, especially if the trees are to be banded.

Broken or split limbs should be removed, and holes, cracks, and narrow crotches, where larvae are likely to hide, should be filled with concrete or other suitable material. Concrete has proved satisfactory for this purpose.

The upper part of the tree should be scraped first, leaving the crotch to be thoroughly cleaned out after all scraping above has been finished.

The most satisfactory scraping tools are a box or tree scraper (fig. 4, *A*) for use in removing the rough bark, and a long-handled, narrow

blade, which is used to gouge into cracks too narrow for the scraper (fig. 4, *B*).

Banding

By the middle of June, or just before the first worms leave the fruit, scraping should be followed by banding, using corrugated-paper bands treated with beta-naphthol. These should contain a minimum of 2 pounds of chemical to each 100 linear feet of 2-inch band. They should be prepared by using 1 pound of beta-naphthol to 1½ pints of heavy oil. In sections of the country where there is much more summer rain than in Yakima County, a larger dosage of 2 pounds per 100 linear feet should be used (Baker *1*). Chemically treated beta-naphthol bands may be obtained commercially in most sections of the country. When properly prepared and used they have consistently given practically 100 percent kill of all larvae entering them in the Yakima and Wenatchee districts. The bands should be placed around

FIGURE 4.—Tools used in scraping apple trees: *A*, Tree scraper; *B*, gouge for cleaning out narrow cracks and crotches.

the trunks, well up near the forking of the scaffold limbs (fig. 5), or on the limbs a foot or so above the crotches, or on both trunk and scaffold limbs.

As an aid in the banding operation a reel for carrying the rolls of banding material (Yothers and Carlson *23*) will be found advantageous and can be made as shown in figure 6. Where two persons work together a rod inserted through the handle will enable several rolls to be carried on the spindle at one time.

In a single season's test, treated bands on sprayed apple trees from June 10 to September 4 showed by chemical analysis a loss of approximately 50 percent of the beta-naphthiol. The quantity remaining, however, was sufficient to kill the larvae that would have transformed to moths the same season.

Band Removal

The bands should be removed and burned before moth emergence begins the next spring to destroy any live larvae present and to prevent a new crop of worms from entering. Old bands that remain on the trees from the year before contain so little chemical that they would kill very few of the larvae the second season, and will do more

FIGURE 5.—Beta-naphthol corrugated-paper band on apple-tree trunk.

FIGURE 6.—*A*, Reel for carrying beta-naphthol banding rolls; *B*, reel with roll in position.

harm than good by furnishing the best possible cocooning quarters (fig. 7).

The most practical time to remove and destroy the bands is at scraping time, when they are a convenient aid in burning the scrapings.

Examination of the beta-naphthol bands after they have been on the trees a few months in badly infested orchards will show considerable numbers of dead and live larvae attached to the bands (fig. 8), to the bark between the band and the tree, and inside the corrugations. The live worms are recent entrants, but most of them will be killed

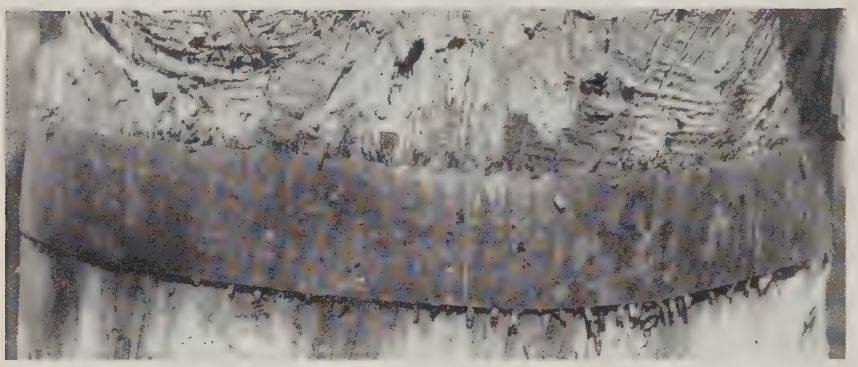

FIGURE 7.—An old beta-naphthol band that has lost all its value but is allowed to remain on the tree affords highly suitable quarters for the larvae. Empty pupal cases are shown at the edges of this old band.

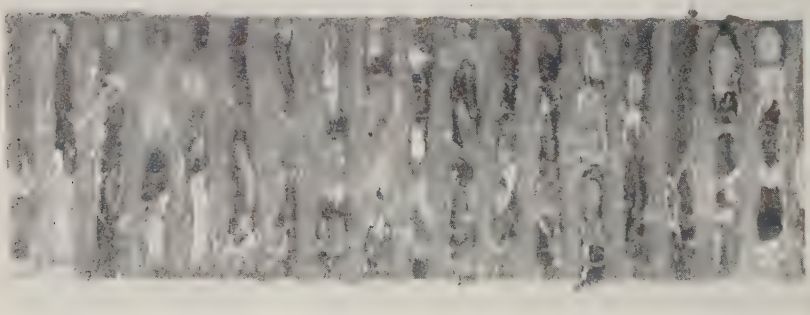

FIGURE 8.—Section of beta-naphthol band showing dead larvae.

within a few days. The larvae entering late in the fall after cool weather has set in will be killed during the winter, but it will take longer to kill them at that time.

COST OF SCRAPING AND BANDING

The cost of scraping and banding depends on so many variable factors that it is impossible to set a definite figure. Some of the factors are the size, age, variety, and general physical condition of the trees, and the prevailing wage and cost of materials (bands, tacks, scraping tools, and tarpaulins).

The most important factors are the size of the trees and the per hour cost of labor. The approximate cost of the two operations for small,

medium, and large trees at a wage of 60 cents per hour is shown in table 6. Bands on both trunks and limbs on older, larger trees would triple the cost for the banding (but not for the scraping) and would increase the total costs by 30 to 40 percent. The worm captures would, however, be increased by approximately 50 percent. Estimates on the net gain from scraping and banding under certain conditions are given by Yothers and Carlson (*26*).

TABLE 6.—*Approximate cost of scraping and banding apple trees in the Yakima district of Washington*

Size of tree	Maximum fruit yield per tree	Time required for scraping	Cost per tree		
			Labor (average at 60 cents per hour)	Material	Total
	Boxes	*Minutes*	*Cents*	*Cents*	*Cents*
Small (rough bark)	10–15	10–15	10–15	3– 5	13–20
Medium	20–35	20–35	20–35	5– 8	25–43
Large	40–50	40–50	40–50	8–10	48–60

SUMMARY

Investigations on the value of scraping and banding apple trees to destroy the larvae of the codling moth (*Carpocapsa pomonella* (L.)) and related studies were carried on near Yakima, Wash., from 1935 to 1943.

On trees not previously scraped and banded 85 percent of the overwintering larvae were located on the trunks and scaffold limbs, 13 percent on other branches, and the remainder in trash and soil. On such trees 86 percent of the larvae were in rough bark and crotches. On trees that had been scraped and banded the previous season, only 41 percent were on the trunks and scaffold limbs, 50 percent on the secondary branches, and 9 percent in trash and soil. Only 46 percent of the larvae were in rough bark and crotches. The average population per tree, however, was reduced from 168 to 22.

Thorough scraping at any time between apple harvest and moth emergence the following spring destroyed about 80 percent of the overwintering population the first season. On trees that had been scraped the previous year only about 50 percent of the larvae were removed by the second scraping.

On well-scraped trees 50 to 60 percent or more of the larvae were trapped in the bands.

Chemically treated bands on the scaffold limbs caught 29 percent more larvae than did bands on the trunks, and a combination of both trunk and limb bands caught 50 percent more than did trunk bands alone.

The heavier the infestation the greater was the proportion of larvae caught in bands as they were leaving the fruit.

Scraping and banding were most effective on varieties such as Jonathan and Rome Beauty, which were readily scraped.

Larvae entering beta-naphthol bands were killed within a few hours to a day or so. The higher the temperature the quicker was the kill.

Sticky banding materials were comparatively ineffective.

In three orchard experiments reductions in wormy fruit amounted to 49, 37, and 58 percent. The average for all tests showed an increase in clean fruit of 37.5 percent in favor of scraping and banding as a supplement to customary spray programs.

Scraping involves the removal of the rough bark, the clearing out of cracks, crotches, and holes, and the removal of rotten and split limb stubs and, as far as possible, other places in which the larvae usually cocoon. Scraping should be done in the fall, winter, or spring, before moth emergence starts. The scrapings should be caught on a tarpaulin and burned.

In recent years banding has consisted in the application of corrugated paper bands, previously treated with beta-naphthol and heavy petroleum oil, about the trunks or scaffold limbs to capture and kill the full-grown larvae that have left the fruit and are seeking cocooning or pupating quarters. Bands should be applied in June, just before larvae begin leaving the fruit, and may be allowed to remain in position until the following spring. They should be removed and destroyed before moth emergence starts.

When labor is available at 60 cents per hour, scraping costs 10 to 50 cents per tree, depending on size, age, variety, and physical condition. At 1 cent per foot, banding material costs 3 to 10 cents per tree, bringing the total cost of banding and scraping to 13 to 60 cents per tree.

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